PROJECT REPORT FORM

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PAGE 61 TO 65
SIGNED H. B. Goodman
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MACHINE SPLICING OF TWISTING TISSUE

INTRODUCTION

A method in general use among paper makers for splicing machine breaks at the rewind stand consists of heat sealing the lapped ends on each side of the break by means of a strip of thermoplastic tape material. This material is normally nontacky and can be easily and conveniently handled. It heat seals at temperatures ranging from 180° F. up to the scorch point of the paper to give firm joints which can be separated only by slowly peeling back one edge.

The principal objection to this method of splicing in connection with the manufacture of twisting paper is that the splice is too bulky. International's 14-lb. twisting paper, for example, has a double weight caliper of 3.6 - 3.8 mils. The caliper of a splice of this kind varies from 5 to 6 mils, depending on the temperature of the heat seal. Thus, the sealing tape itself causes an increase in thickness of 40-70%. Efforts have been made to reduce the splice thickness by using a latex adhesive applied with a brush. These, however, were unsuccessful due to the latex striking through to the under layers of paper in the roll and causing blocking.

It is ~~the~~ desired, therefore, that this group conduct an investigation of methods which in addition to decreasing splice bulk would be free of blocking problems, be convenient and time-saving to apply.

and would produce splices of durability comparable to those now obtained. A supply of 14-lb. (36 x 24 x 500 ream) twisting tissue was available from previous work.

EXPERIMENTAL WORK

The entire field of adhesives was open for consideration in connection with this problem of splicing. The applicable types of adhesives could feasibly come under the classification of thermoplastic or thermosetting, water systems, solvent systems, organasols, plastisols, or hot melts. The types of application were somewhat limited in that air drying of water release adhesives and even some solvent release adhesives was too time consuming. However, since heat-sealing methods were now in use, there was no particular reason why such adhesives could not be dried and heat sealed in one operation or in the case of thermosetting adhesive why the heat sealing could not instead be a curing operation. In addition, it was possible that a tape similar to that now in use could be obtained but which was thinner and had more plastic flow during heat sealing.

With this in mind, two water-type adhesives were tried first inasmuch as water usually involves less complications in its removal than do most solvents. A polyvinyl acetate emulsion, Gelva TS-35*, and a butadiene-styrene (70% styrene) latex, Darex Copolymer 9L**, both thickened with CMC*** resulted in fairly thin splices having ample adhesion but

*Manufactured by Shawinigan Products Corp.
**Manufactured by Dewey and Almy Chemical Co.
***Carboxymethyl cellulose--manufactured by Hercules Powder Co.

were unsatisfactory both in respect to wrinkling and strike through of the adhesive during heat sealing. Both materials were brushed on and the joints heat sealed while still damp.

Since it was seen that adhesives involving water introduced a wrinkling problem, the next consideration was that of thermoplastics applied as solvent cements and heat sealed to remove the solvent and force the adhesive into a thin layer. Table I lists the materials tried and their results. Included with the solvent release type adhesives in Table I is an adhesive which, though not a true plastisol, approaches it in nature, the only difference being that a very small amount of solvent (methanol) was added to improve stability. This material required a heat sealing temperature of 450° F. or higher in order to adequately fuse the vinyl resin and cause good adhesion.

The heat sealing was done with a household type iron having no thermostat. Temperatures consequently varied considerably but were generally in the neighborhood of 300-450° F. Within these limits, the only property ordinarily affected by temperature variation was the splice thickness, the higher temperatures resulting in thinner splices. In the case of "Grippit", better adhesion also was obtained at higher temperatures.

In the evaluation of adhesive strength, very few materials failed under a shear stress such as would occur when the spliced sheet is under tension. More frequently, stripping tests at 90-180° pull back indicated failure of the bond. However, this test was to a large degree dependent on the speed of pull back. A sharp jerk usually

TABLE I

COMPARISON OF SPLICING ADHESIVES AS APPLIED TO INTERNATIONAL TWISTING TISSUE

Adhesive Material	Heat Sealing	Blocking or strike through	Adhesion	Caliper of Splice	Flexibility of Splice
1 part, Vinylite AYDW* 1 part, Dioctyl phthalate about 20% in methanol	wet	yes	excellent	over 4 mils	fairly stiff
	dry	no	excellent	over 5 mils	fairly stiff
3 parts, Vinylite AYDW 7 parts, Dioctyl phthalate as plastisol with small amount methanol to increase stability.	wet	no	excellent above 450° F.	5 mils	stiff
Vinylite AYDW about 10% in acetone	dry	no	excellent	4 mils	stiff
10 parts Vinylite AYDW 6 parts or 2 parts, Dioctyl phthalate	wet	no	poor	-	-
2 parts, Vinylite VYNW* 1 part, Tricresyl phosphate about 30% in M.E.K. and ethylene dichloride	wet	no	poor	-	-
2 parts, Vinylite VYHH* 1 part, Tricresyl phosphate about 30% in 1-1 toluene, M.E.K.	wet	no	poor	-	-
2 parts, Vinylite VYHH* 3 parts, Paraplex G25* about 30% in 1-1 toluene, M.E.K.	wet	no	poor	-	-
Vinylite VMCH* about 30% solids solvent unknown	wet	no	good	4 mils	stiff

Vinylseal 28-14* diluted over wide range with ethyl acetate	wet	no	excellent	4 mils and less	stiff
Grippit*, undiluted	wet	no	good if heat-sealed above 400° F.	less than 4 mils	flexible
Dekadhese*, undiluted	wet	no	good	4 mils	stiff
Dupont thermoplastic cement #4620, undiluted	wet	no	poor	-	-
Dupont thermoplastic cement #4639, undiluted and diluted to 15% solids with ethyl acetate	wet	no	excellent	4 mils and less	stiff
1 part, 5 pass smoked sheet 1-1/2 part, Staybelite resin* 1-1/2 part, Polypale resin*	wet	no but some strike through	slightly better than Grippit under 400° F.	less than 4 mils	flexible
Ditto plus 1% Sulfur and 1% Methyl Tuads* on rubber	"	"	"	"	"

* Vinylite AYDW polyvinyl acetate (water dispersable)
Vinylite VYNW polyvinyl acetate-chloride copolymer
Vinylite VYHH " " " "
Vinylite VMCH " " " "
Vinylseal 28-14 methyl acetate solution of modified polyvinyl acetate
} Bakelite Corp.

Paraplex G25- unmodified sebacic acid polyester - Rohm & Haas Co.

Grippit- an office paper cement - Harriman-Welts Inc.

Dekadhese- a general purpose cement - Technical Specialties Co.

Staybelite resin- hydrogenated rosin - Hercules Powder Co.

Polypale resin- polymerized rosin - " " "

Methyl Tuads- tetramethylthiuram disulfide - Sharples Chemicals Inc.

caused fiber failure except in cases of very low adhesion while a slow peeling back could separate both plies without fiber failure except in a few cases.

The double weight caliper of the twisting paper used was about .0036" - .0038". Table I indicates approximate splice calipers. It can be seen that in many cases the actual thickness of the adhesive layer is negligible.

Samples of splices together with samples of the adhesives used were sent to Mr. Bailey of the Niagara Falls mill of International Paper Company for their evaluation in the case of Vinyseal 28-14, Dupont thermoplastic cement #4639, Grippit, and both rubber cement preparations.

SUMMARY

Although there is meager quantitative data in Table I upon which to base any conclusions, there are a few generalities which may be pointed out.

Vinylite AYDW and VYHH are poor adhesives in the presence of plasticizers. However, the vinyl type adhesives in general are quite good without plasticizers except from the standpoint of flexibility. This is true also of the Dekadhese and Dupont cement #4639 the exact composition of which are unknown but which are supposedly thermoplastic materials such as vinyl polymers or possibly cellulose derivatives. With these materials very thin splices are possible with no blocking but the fact that they lack flexibility may be just as undesirable as if they were bulky.

Grippit and rubber cement preparations showed greater flexibility and even lower caliper splicing possibilities. However, the adhesion of these adhesives was more a pressure sensitive type and splices were subject to being peeled apart as are the conventional splicing tape splices. It is possible that the rubber cement preparations could be worked out which would have superior adhesion to those listed. There was no particular evidence of vulcanization of the rubber in the preparation containing sulfur and accelerator. Ordinarily, vulcanization would tend to result in higher adhesion, and more work along this line might prove beneficial. Although not listed in Table I, one rubber cement preparation was used which had a considerably higher resin to rubber ratio, but this increase only tended to decrease the flexibility and not do much for the adhesion. Other possibilities in the line of rubber cements are the use of synthetic rubbers such as butadiene-acrylonitrile copolymers or cyclized rubber, the use of other tackifying resins such as coumaranone-indenes or pinenes, and finally the use of a heat stabilizer such as phenyl beta napthamine to prevent loss of adhesion during heat sealing.

rbg/mmm

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SIGNED John M. Dowd
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FURAN COMPOUNDS AS WET-STIFFNESS AGENTS FOR PAPER

INTRODUCTION

At some unspecified time, a brief test had been made by Dr. Rowland in which he found a considerable increase in the wet-stiffness of board treated with furfural (or possibly furfuryl alcohol). Apparently, the test was never followed up and no written record was found. The following tests were made to determine whether or not we would be justified in suggesting to Quaker Oats Company that this possible application be investigated under Project 1021.

An attempt was made to discover the effect of the following list of independent variables on the wet-stiffness.

1. Different compounds
2. Concentration
3. Solvents
4. Drying conditions
5. pH
6. Effect on different papers.

In addition, a determination was made of the amount of compound used per unit weight of paper.

MATERIALS USED

A light paperboard, basis weight 168 pounds
A corrugating paper, basis weight 75 pounds
Furfural (tech)
Furfural (redistilled)
Furfuryl alcohol (tech)
Acetone U.S.P.
95% ethyl alcohol
0.517 N sulphuric acid

PROCEDURE

The following solutions were prepared:

Furfural (tech) in acetone	100%, 50%, and 10%	by weight.
Furfural (redistilled) in water	100%, 9%, and 5%	by weight.
Furfuryl alcohol in 95% ethyl alcohol	100%, 50%, 10% and 5%	by weight.
Control Solution	aceton U.S.P.	
Control solution	95% ethyl alcohol	
Control solution	water with pH adjusted to 2.7 by adding HCl.	

The acetone and alcohol solutions were used at two acid concentrations by adding to each 200 gram sample 1 ml. of 0.517 N sulfuric acid, then after paper samples had been treated, an additional 9 ml. of acid was added to the solution before treating the remaining samples. No acid was added to the furfural-water solution.

An investigation of the pH of the furfural solutions, both in water and in acetone, indictated that the furfural was decidedly acidic without the addition of acid. The detailed results are contained in Table I.

Samples (2" x 12") of the two papers used were treated with the above solutions by dipping. One set of samples was air dried several hours, another set was oven dried for 1/2 hour at 100° C. All of the samples were then soaked in tap water overnight and subjectively hand-tested for wet stiffness.

TABLE I

pH TESTS OBTAINED WITH THE MacBETH pH METER

Acetone Solutions	Indicated pH
100% furfural	2.5
100% furfural (redistilled)	2.8
100% furfural + acid (10 ml. 0.517 N) (per 100 grams)	1.3
50% furfural + acid (10 ml. 0.517 N) (per 200 grams)	0.3
100% acetone	7.5
Water Solutions	
5% furfural	3.3
9% furfural	3.5

The results of these wet-stiffness tests are summarized below.

1. Furfural was decidely more effective than furfuryl alcohol (estimated twice as effective). Both compounds, however, increased wet-stiffness.

2. Increase in stiffness was roughly proportional to increase in concentration to at least 50%. The increase in stiffness between 50% and 100% seemed to be slightly less than would be expected from a doubling of the concentration.

3. No noticeable difference in stiffness between aqueous solutions and acetone solutions.

4. Oven dried samples were noticeably stiffer than air dried samples.

5. The effect of increasing acid concentration was not detectable.

6. The heavier paper seemed to be improved more. However, this might easily be an error of observation due to the fact that all samples of the lighter paper were so lacking in stiffness that a change in stiffness would be more difficult to detect than in the case of the stiffer paperboard.

7. The increase in wet-stiffness of the furfural impregnated sheets (50% and 100%) amounted to several hunder per cent above the control samples.

Determination of furfural pickup:

An attempt was made to determine furfural pickup on the basis of dry condition, but results were inconsistent and not conclusive.

Another system of determining pickup on the wet condition was devised as follows:

Sheets of the lighter of the two papers used above were weighed (air-dry), treated by putting through a set of paper covered wringer rolls under some pressure, allowing the paper to dip into the furfural solution just before reaching the rolls. The paper was weighed immediately after passing through the rolls. Results listed below.

Solution (Aqueous)	Pickup on Airdry Weight of Paper, %	Furfural Pickup on Airdry Weight of Paper, %
100% furfural	84	84
5% furfural	147	7.4
water	143	-

CONCLUSIONS

Furfural warrants further investigation as a wet-stiffness agent. If concentration less than 100% and greater than 9% are required in water solution, it will be necessary to find a method of emulsifying the furfural since it is not water soluble in greater than 9% concentrations.

jmd/lah

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SURVEY OF THE USE OF REDWOOD HEADRIG SAWDUST IN THE MANUFACTURE OF BUILDING AND INSULATING BOARD

INTRODUCTION

Upon the suggestion of Dr. Lewis work was initiated to survey the possibility of using redwood headrig sawdust in the manufacture of an insulating or building board. The work done to this time covers a general investigation of the possibilities and did not go into any of the details that would be involved in an extensive research project.

MATERIALS AND METHODS

The sawdust used was sawdust from the headrig sawing operation of The Pacific Lumber Co. The thermosetting resin used in this phase of the work was Durez resin 10650. This resin is recommended by the manufacturer for applications of this type. The resin cures quite rapidly and has better than average flow. The thermoplastic resin used was Vanadiset resin Grade C from the Wilson Carbon Co. It is quoted as being an aruba bitumen and gets its name from the small percentage of vanadium pentoxide in the material. In some of the work, the panels were surfaced with a resin impregnated paper. This paper is a Kimberly-Clark product retailing under the trade name of Kimpreg. This paper has a high resin content in the neighborhood of 40-50%. Redwood Asplund fiber was also used in some of the boards as was Redwood Plastic Pulp.

DISCUSSION

The first phase of the work was concerned with the use of a thermosetting type binder for the sawdust. The resin used (Durez 10650) is used in industry for similar applications. The resin comes as a fine dry powder and sells for 27-30¢ per pound. The dry resin was mixed cold with the sawdust in a Baker Perkins mixer. The resin content was 10% based on the weight of the sawdust. The blended material was then molded in a disk mold at various temperatures and pressures. The most satisfactory temperature seemed to be about 320° F. The pressures tried ranged from 500-6000 p.s.i. The higher pressures produced a dense board which held together quite well but had very poor nailing properties. The lower pressures produced a board of lower density but had rather poor strength properties including nailability.

It was thought that by replacing 20% of the sawdust with redwood Asplund fiber the over-all picture would be better. The Asplund fiber did add cohesion and nailability to the board, but the board did not seem too practical under these conditions. The cost for this type of board would be $8-$10/1000 square feet.

The next phase of the work involved the use of a thermoplastic type binder. The resin chosen was Vanadiset resin Grade C. This resin softens at 320-340° F and sells for 3-4¢/lb. The

first boards made up were a mixture of 30% Vanadiset, 20% Asplund fiber, and 50% sawdust. The first trials were made in the disk mold with a molding cycle of 5 minutes at 600 p.s.i. at 150 lbs. of steam. The dry materials were blended in the Baker Perkins mixer. The resultant boards had a high density and good hardness. It appeared that a cutback in resin content could be tolerated. The next boards were made up using 20% resin, 60% sawdust, and 20% Asplund fiber. The board was molded at 300 p.s.i. at the same time and temperature. The board was less dense but showed signs of poor resin distribution. It found that a better dispersion of the resin could be achieved by using pulverized Vanadiset and heating the Baker Perkins during the mixing.

It was found that bigger panels could be made by spreading the material evenly on a caul and pressing with another caul over the top. In order to eliminate the necessary chilling cycle and to improve the general properties of the board, it was decided to surface the boards with a resin impregnated paper. This was done at the same time the boards were pressed. These panels were made up using 1-12 sheets per side. A panel was made up using a sheet of impregnated paper in the center. All of these boards showed better properties than those without, but the panel surfaced with one sheet had a tendency to split when removed from the press. The single sheet was too brittle and lacked the necessary strength. A large sample using two sheets per side was made up and sent to Mr. Thompson of The Pacific Lumber Company.

Representative cost figures for materials used in such a board are listed below. These figures are quoted on the use of 2 surface sheets per side.

MATERIAL	AMOUNT 1000 sq. ft. 1/2 inch thick	UNIT COST	COST per 1000 sq. ft.
Kimpreg	15 lbs.	$0.30	$4.50
Vamadiset	52	.04	2.08
Total			$6.58

A panel was made using Plastic Pulp in place of the Asplund Fiber. This replacement showed no significant differences but might be worth further investigation.

CONCLUSIONS

From the brief study that was made it appears that the use of a thermosetting resin would not be feasible unless the market could bear the cost and providing a satisfactory product could be made.

The use of a thermoplastic resin seem to offer a great deal of promise. The particular resin tried is as cheap as one might expect with the market conditions as they are today. The use of the surface sheets also seems to be desirable. The addition of a fibrous material of some sort or the other definitely adds to the strength of the board.

SUGGESTIONS FOR FUTURE WORK

The following points might be of interest for further investigation.

1. Investigate the use of other fibrous materials to add to the sawdust.
2. Investigate the effect of the sawdust particle size.
3. Evaluate other resins.
4. Try to find a better surface sheet, possibly a heavier sheet.
5. Investigate the use of some redwood extractives as binders.

vck/mc

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THE PHASE MICROSCOPE IN THE STUDY OF WAX

INTRODUCTION

Since The Institute of Paper Chemistry has acquired a phase microscope it was felt that its potentialities in the study of waxes should be investigated.

The microscopic study of waxes is hampered by the transparency of the wax, especially when using ordinary transmitted or reflected light. The polarizing microscope has also been reported as of value in observing wax crystals. However, the contrast is not very satisfactory.

The phase microscope construction is based on the principle of light interference. The back of the objective lens is coated with a circular annulus of light diffracting material and in some cases light absorbing material. The condenser system is equipped with annular diaphragms to match the objectives. Each microscope objective is provided with its own annular diaphragm on a turret head condenser.

It is possible to cause the material being studied to appear lighter or darker than the surrounding media by the selection of the proper combination of objective and annular diaphragm. Three types of contrast—Bright, Dark and B Minus—are available in three degrees of intensity of contrast—high, medium and low.

PROCEDURE

Preliminary visual observations were made on commercially waxed paper and on wax crystallized on glass slides.

It quickly became apparent that the light absorption by a coated opaque waxed paper was too great for photomicrographs. It was also observed that the wax coating must be quite thin or reversals in contrast and a confusing result is produced.

Attempts to form a thin coating of wax on a microscope slide by using a microscope cover glass were not satisfactory as the natural crystal growth was restricted. The wax would not flow out over the heated microscope glass slide but would draw up into small droplets. Apparently the wax in a molten state would not wet the hot microscope slide.

General Electric Company Drifilm was tried as a means of developing a nonpolar surface on the glass. A few drops of the liquid monomer were vaporized on a small hot plate directly under the glass slide. This gave a slight improvement in the contact angle between the melted wax and the treated glass slide.

Lucite, a methylmethacrylate polymer, showed good wetting by the molten wax and efforts to improve on the technique of using the Drifilm were dropped. However, the thickness of the plastic sheets at

hand was too great for convenient use with the microscope. The plastic is easily scratched, and cleaning of the slides is difficult if scratches are to be avoided.

A 0.2% Formvar solution in ethylenedichloride was tried as a dip for the glass microscope slides. The dipped slides were air dried in a vertical position to leave as thin a film on the glass as possible. Good results were obtained with the slides prepared in this manner. The slides were very transparent and were wet well by the melted wax.

Using Formvar coated microscope glass slides, specimens of various waxes were prepared. Phase photomicrographs were taken of the specimens at a 100 x magnification. These are shown in figures 1a through 7a.

During the preliminary visual observations it was discovered that the phase microscope could be used to bring out an oblique lighting effect. This was accomplished by moving the turret head so that the light from the annular diaphragm reached the specimen from one side only. In the normal phase microscopy peripheral lighting is used. The oblique lighting was used to prepare the photomicrographs shown in figures 1b through 7b. The oblique lighting may be used to emphasize certain aspects of a photomicrograph. For example, the fractures present in 6b are more pronounced than in the phase photomicrograph shown in 6a.

The specimens were prepared by warming a Formwar coated glass slide over a small thermostated hot plate; a small amount of wax was melted directly on the slide; the excess wax was poured off as soon as the slide had been coated; the slide was then placed in a vertical position in a heated oven until a very thin film of wax was left. The wax was cooled by allowing the slide to cool at room temperature in a horizontal position, or by quick chilling by thrusting the hot wax-coated slide into an ice water bath, or by slow cooling by allowing the slide to cool slowly by leaving it in the oven and letting the oven cool off.

RESULTS

The photomicrographs are pictures taken of the following materials:

1a. Phase photomicrograph of Sunoco 1290 Yellow, a high (180° F.) melting point microcrystalline wax--cooled at room temperature.

1b. Oblique lighting of Sunoco 1290.

2a. Phase photomicrograph of Socony Vacuum 124-127° F. fully refined paraffin cooled at room temperature.

2b. Oblique lighting of Socony Vacuum 124-127° F. fully refined paraffin.

3a. Phase photomicrograph of Socony Vacuum Magnowax--a 160° F. ASTM melting point microcrystalline wax cooled at room temperature.

3b. Oblique lighting of the Magnowax.

4a. Phase photomicrograph of Socony Vacuum 138-140° F. fully refined paraffin cooled at room temperature.

4b. Oblique lighting of Socony Vacuum 138-140° F. paraffin.

5a. Phase photomicrograph of a blend of 3/4% Vistanex B-100, 1.0% DYGT polyethylene in 132-134° F. ASTM fully refined paraffin (Standard Oil).

5b. Oblique lighting of the blend.

6a. Phase photomicrograph of Socony Vacuum 138-140° F. fully refined paraffin quick chilled.

6b. Oblique lighting of the quick chilled Socony Vacuum 138-140° F. paraffin.

7a. Phase photomicrograph of Socony Vacuum 138-140° F., fully refined paraffin slow cooled.

7b. Oblique lighting of the slow cooled Socony Vacuum 138-140° F. paraffin.

DISCUSSION

The value of the phase microscope in the study of wax is apparent. The wax structure can be studied by phase photomicrographs. The significance of the structure evidence must, however, be correlated with the other characteristics of a wax. Such a study is too involved for our preliminary survey. The moisture vapor transmission, flexibility blocking resistance and other characteristics related to wax structure would be of interest to the converter.

The small crystal structure of the microcrystalline waxes and the quick chilled paraffin wax is clearly evident. The large crystal structure of paraffin wax cooled more slowly is well illustrated.

The possibility of studying the effect of wax additives on the crystal growth of wax is suggested by the results shown here.

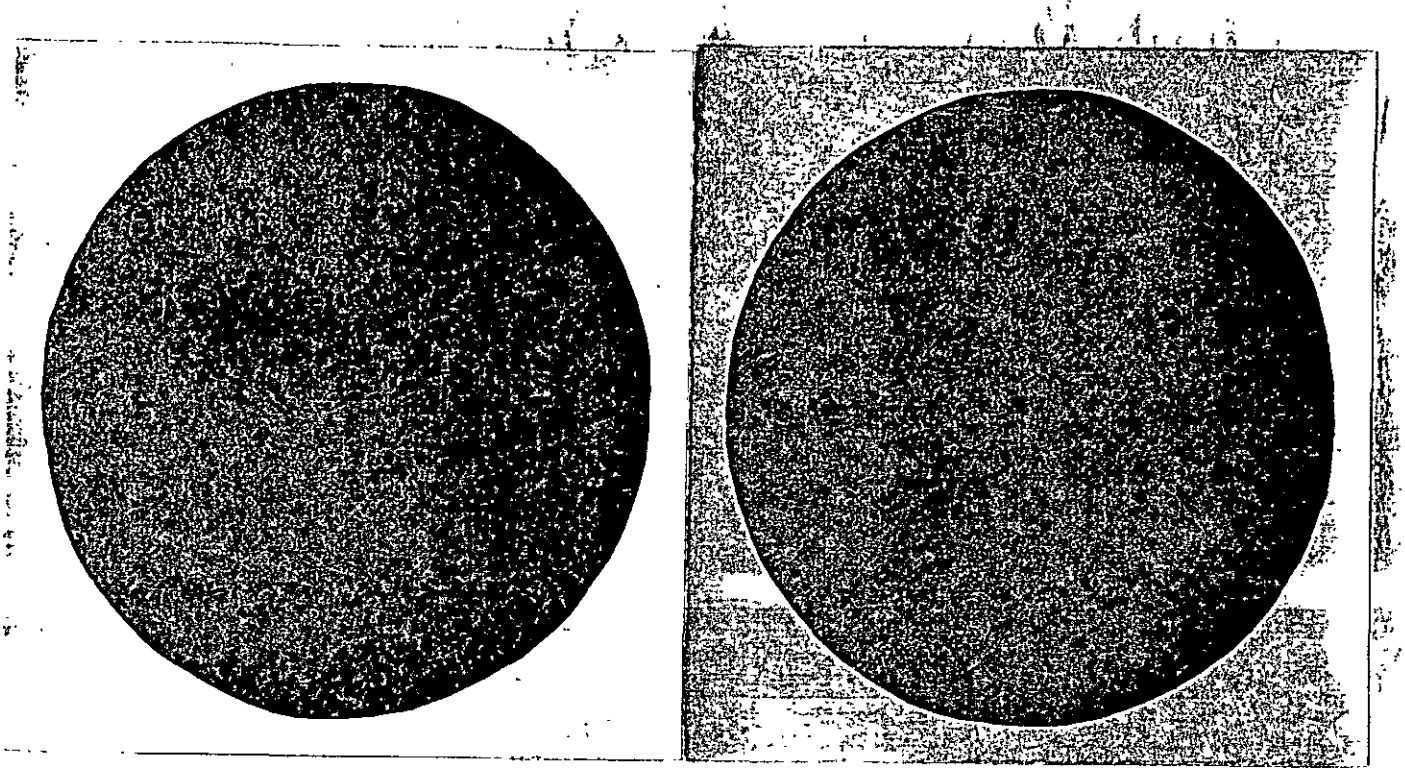
Other techniques, such as replica photographs and shadow graphs of sputtered metal on wax coatings, may prove useful in studying the nature of the wax crystals on a sheet of waxed paper. The use of the phase microscope may be of interest in these applications where without the special techniques it has no value.

CONCLUSIONS

The phase microscope has been shown to be a useful tool in observing and photographing material too transparent to view clearly or photograph well with the ordinary microscope.

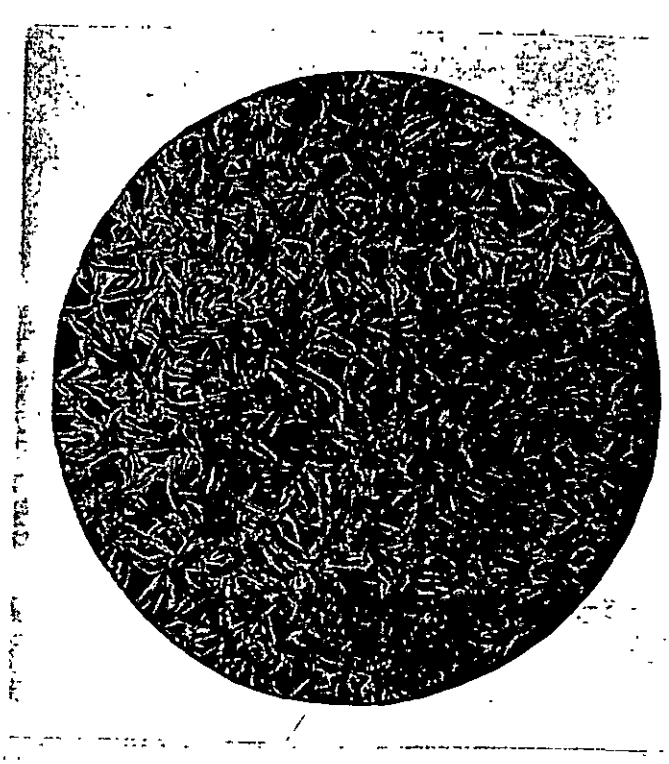
Its use in the study of wax and wax blends is recommended.

fv/mc

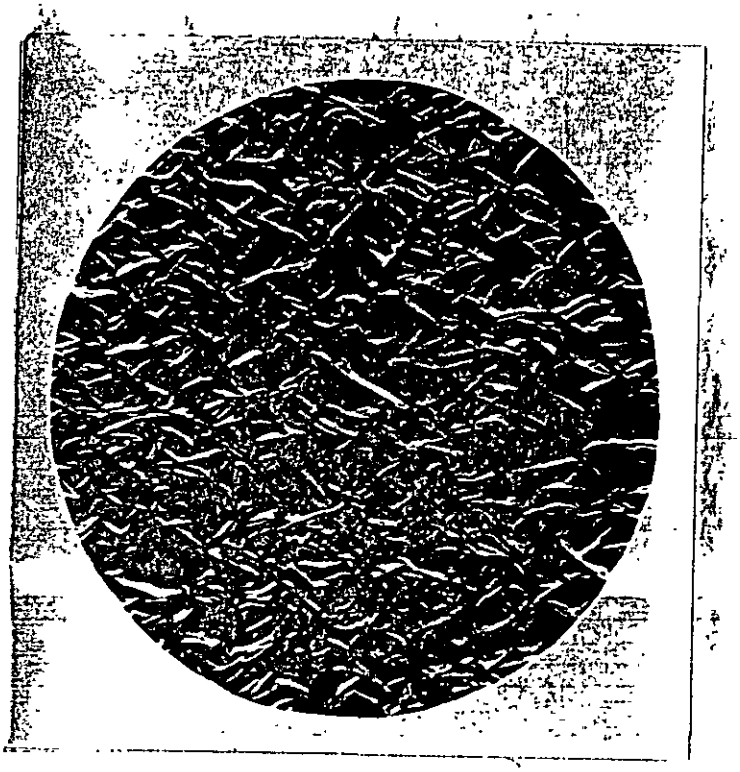


1a Phase Contrast
Sunoco 1290 Yellow
180° F. ASTM Microcrystalline Wax
Cooled at room temperature

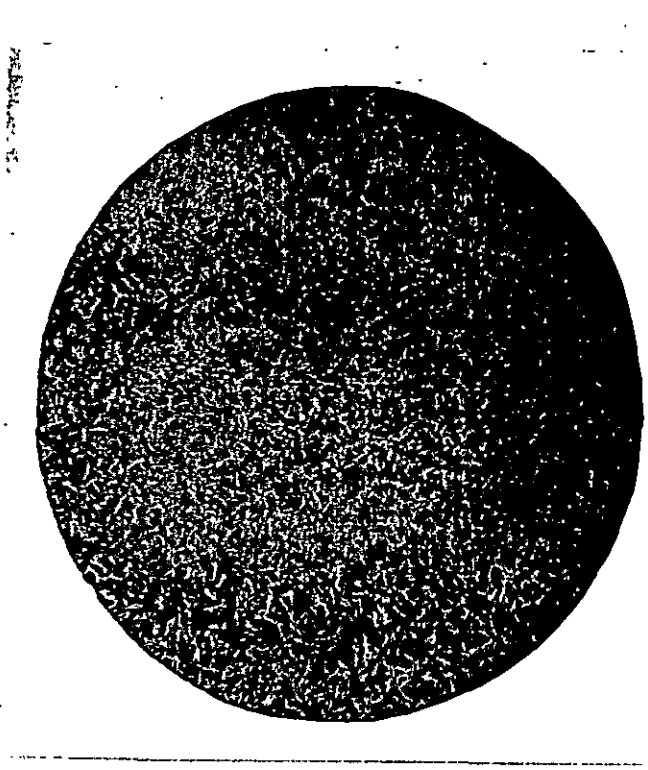
1b Oblique Lighting
Sunoco 1290 Yellow - 180° F. ASTM
Microcrystalline Wax
Cooled at room temperature



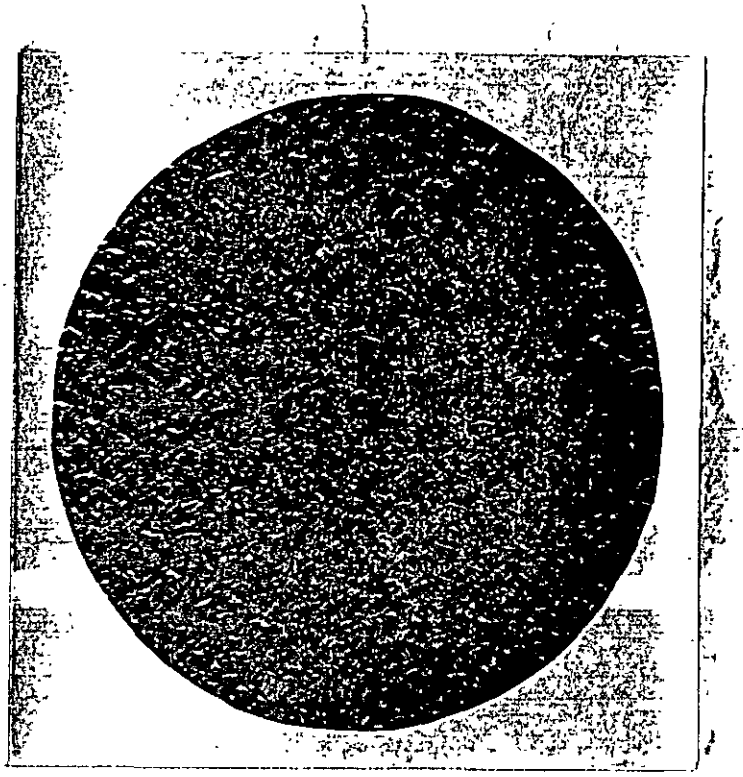
2a Phase Contrast
124-127° F. ASTM Paraffin
Cooled at room temperature



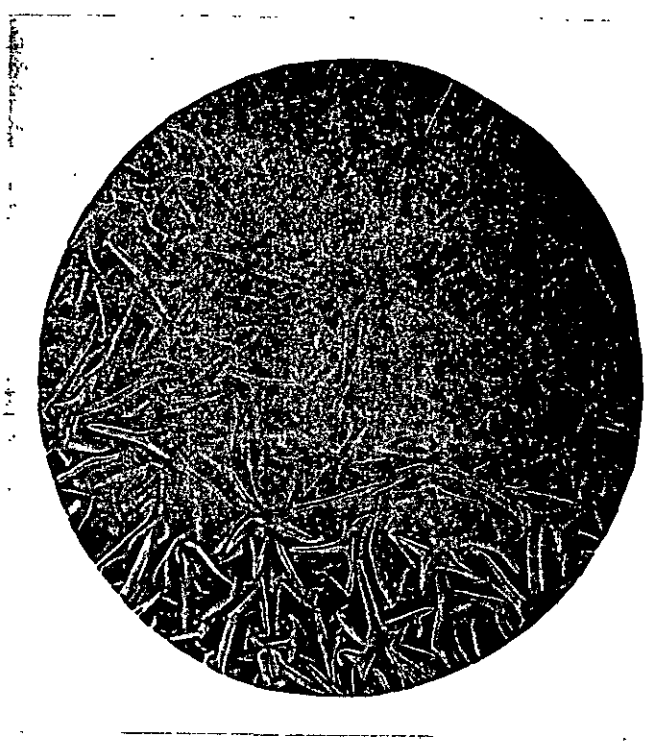
2b Oblique lighting
124-127° F. ASTM Paraffin
Cooled at room temperature



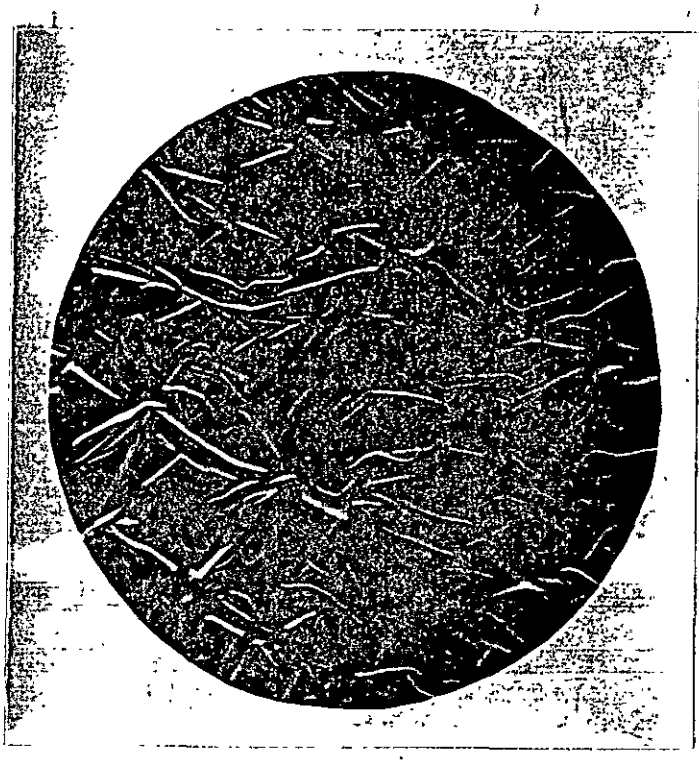
3a Phase Contrast
Magnowax microcrystalline wax
Cooled at room temperature



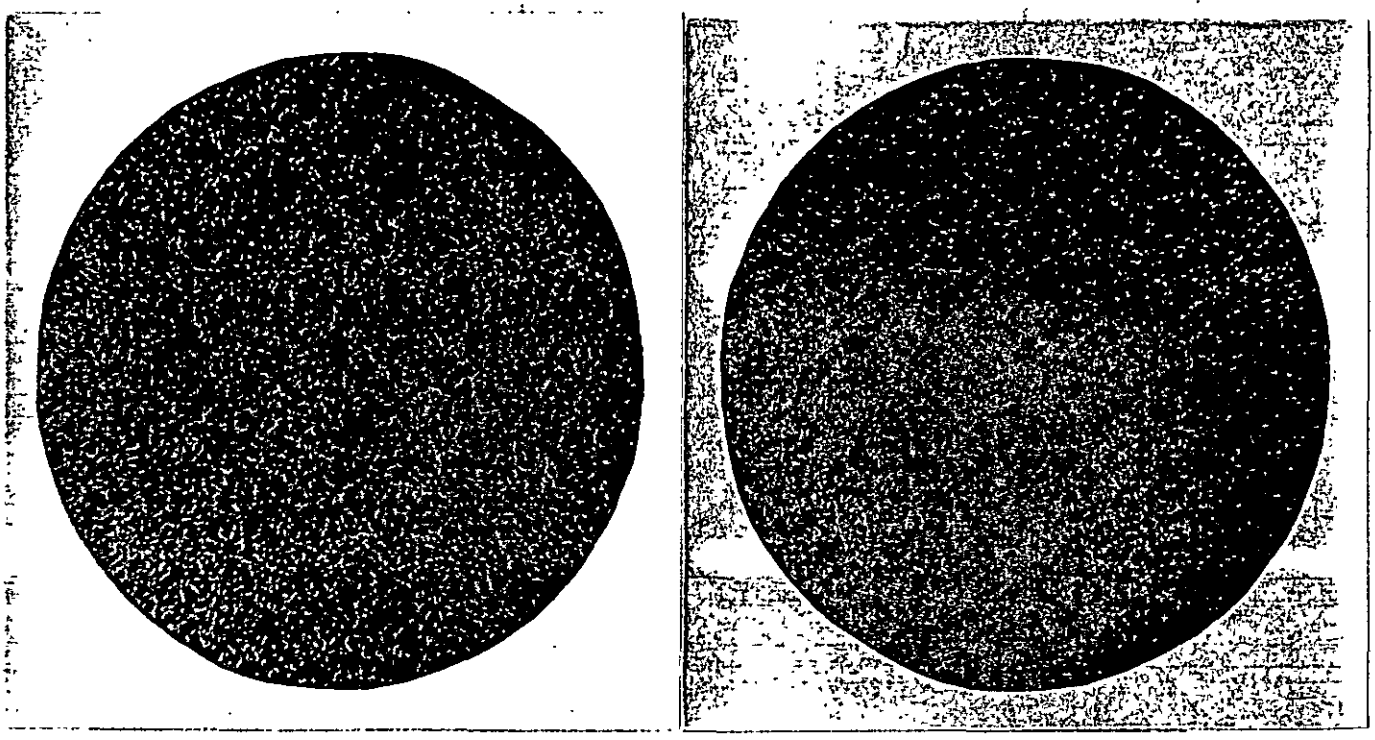
3b Oblique lighting
Magnowax microcrystalline wax
Cooled at room temperature



4a Phase Contrast
138-140° F. ASTM Paraffin
Cooled at room temperature

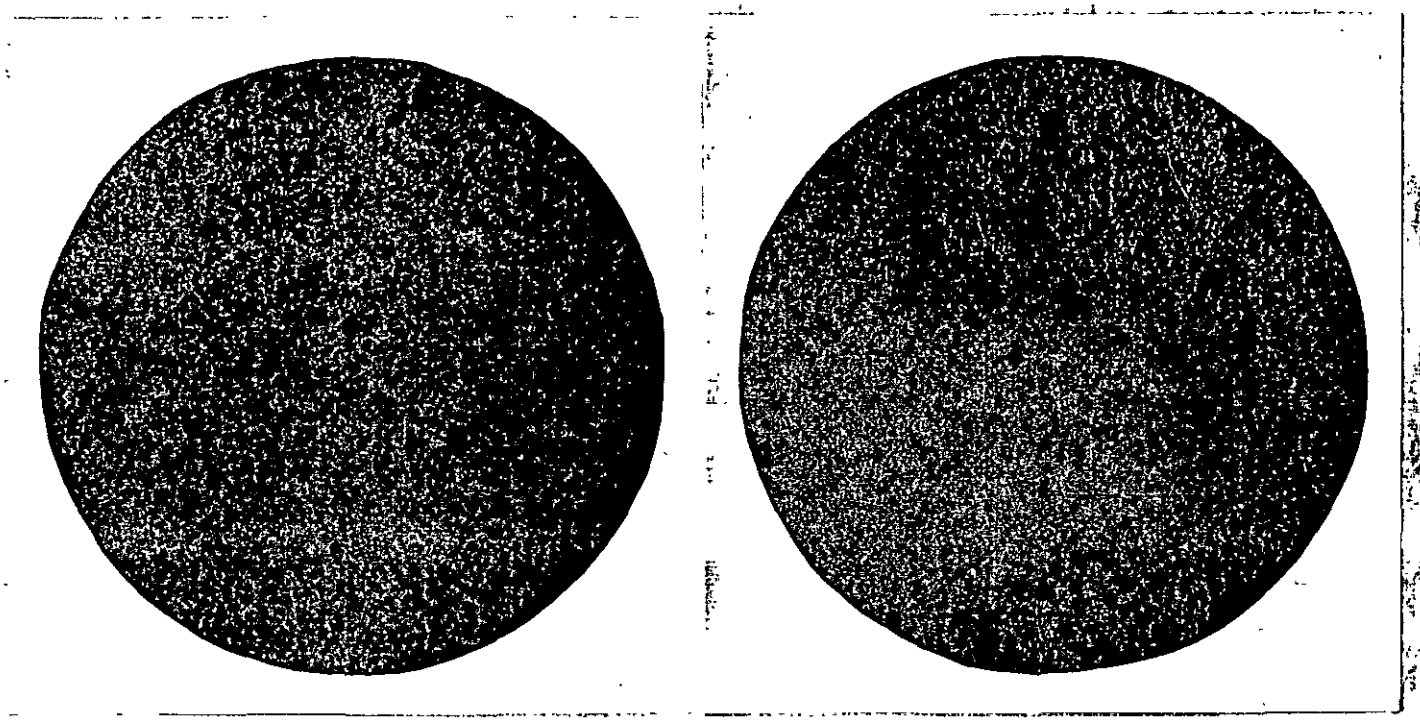


4b Oblique lighting
138-140° F. ASTM Paraffin
Cooled at room temperature



5a Phase Contrast
Blend - 3/4% B-100 Vistanex 1% DYGT Polyethylene in 132-134° F. ASTM Paraffin
Cooled at room temperature

5b Oblique lighting
Blend - 3/4% B-100 Vistanex 1% DYGT Polyethylen in 132-134° F. ASTM Paraffin
Cooled at room temperature



6a Phase Contrast
138-140° F. ASTM Paraffin
quick chill

6b Oblique lighting
138-140° F. Paraffin
quick chill

7a Phase Contrast
138-140° F. ASTM Paraffin
slow cooling

7b Oblique lighting
138-140° F. ASTM Paraffin
slow cooling

1949

PROJECT REPORT FORM

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REPORT NO. 4
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SIGNED R. B. Goodman, Jr.

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PECTATE PULP AS A GREASE RESISTANT COATING FOR PAPER

SUMMARY

A brief evaluation of Pectate pulp, a citrus by-product developed by the California Fruit Growers' Exchange was made in connection with one of its recommended uses--as a cheap, water soluble, grease resistant paper coating. This material will not function as a coating by itself but must be modified by the addition of plasticizer and adhesive agent. Urea and invert sugar were suggested as plasticizers and hide glue as the adhesive. It was found, however, that a less hydroscopic material such as locust bean gum provided sufficient adhesion between the pectate film and paper without having an attendant tacky feeling. The modified pectate films are brownish, rough textured and have a disagreeable odor. At a coating weight of 10 lbs. per 1000 sq. ft. (or $.67 per 1000 sq. ft.) the time of penetration of several oils and greases was found to be in excess of 48 hours. The pectate solutions are fairly difficult to apply because of thixotropic flow characteristics and the presence of air bubbles and gel particles. A knife coater with a high angle of separation between the knife and the coating was found to be quite satisfactory over a wide range of coating weights. A roll gap coater was found to produce ridged coatings at low coating weights. This material would be of interest for a low cost application where color and odor are unimportant and where the coated material would not be severely creased.

INTRODUCTION

Among the uses for Pectate pulp suggested by the California Fruit Growers Exchange was that of grease resistant coatings for paper. A sample of the pulp containing 7.5% sodium-pyrophosphate (a solubilizing agent) was supplied to the Institute and a portion used by the Plastics group for an evaluation of this property. The evaluation followed to some extent the suggestions as outlined in the reprints submitted.

EXPERIMENTAL WORK

The recommended coating formula and procedure for preparation as given in the report submitted is listed below:

6.1 parts	- Pectate pulp
0.4 parts	- $Na_4P_2O_7$
102 parts	- soft water
2 parts	- hide glue (i.e. Swift and Co., Superhesive)
8 parts	- urea
8 parts	- invert sugar syrup (i.e. Nulomoline Co., Nulomoline)
0.2 parts	- Santobrite (preservative, Monsanto Chemical Co.)

Add Santobrite, pulp and phosphate to 100 parts boiling H_2O with high shear agitation; add hide glue predissolved in remaining H_2O; cool to 140° F. and add invert sugar syrup and urea.

The pectate pulp is solubilized (with the addition of phosphate) in boiling water with high shear agitation. For this study an Eppenbach Homer-Mixer was used. In order to avoid overheating it was found

advantageous to use an oil bath at 260° F. as a means of heating. The pectate pulp itself is nonadhesive and requires the addition of an adhesive agent to promote adhesion between the pectate film and the material being coated which in this study was patent coated board. Hide glue was suggested for this purpose. Locust bean gum was also tried in this capacity. Urea and invert sugar were suggested as plasticizers and Santobrite as a preservative for the prepared solution.

Coatings were made on the patent coated board* with solutions of pectate pulp alone, with solutions of pectate pulp modified as per above formula, and with solutions of pectate pulp modified as per above formula but with .061 parts locust bean gum substituted for 2 parts hide glue. All these solutions exhibited poor flow characteristics (thixotropy). In addition, the presence of air bubbles and small gel particles made it difficult to get uniform continuous coatings at low coating weights. This latter difficulty was to a large extent alleviated by vacuum de-airing and pressure filtration through cloth.

Several coating methods were included in this work. The eccentric cylinder film caster was found to produce ridges in the wet coatings at low coating weights but was satisfactory for laying down thick coatings. These ridges do not flow out and are presumably due to interfacial tensions involved with certain types of coating devices in which the angle of separation between the coating and the coating device is low. The Martinson coater, because of the high angle of separation between the blade and the coating, was found to produce non-ridged, uniform coatings at low coating weights (3 lbs. per 1000 sq. ft.) as

* A 20 point board which was supplied by Container Corp. of America for Project 1464, "Development of a Greaseproof Paperboard Coating."

well as at high coating weights. Mayer rods were also found to produce uniform low weight coatings but in order to get coatings of sufficient thickness to afford grease resistance multiple coats were necessary with this method.

Coating weights were determined in most cases by weighing the boards before and immediately after coating. The unmodified pectate films, being nonadhesive, could be stripped from the board dry and weighed directly.

The property of grease resistance (or oil resistance) which was of particular interest in this work was checked in various ways. Surface continuity was established by means of a kerosene penetration test. Discontinuities in this test show up almost immediately as dark spots where the kerosene hits the board. Resistance of the films to the dissolving or softening action of oils was checked by immersing strips of unsupported film in turpentine and kerosene and noting their condition over a period of several days. Using a coating which was established as being continuous, time of penetration, using five oily substances, was determined. These substances were turpentine, lard, corn oil (Mazola), mineral oil (Nujol) and hydrogenated vegetable oil (Spry).

RESULTS

The pectate films in general were brownish, rough textured, and possessed a rather disagreeable odor. The unplasticized films were extremely brittle and those containing no adhesive stripped readily from the surfaces upon which they were formed, namely, glass and patent coated board.

Neither the modified or unmodified pectate films exhibited any degree of water resistance, both softening readily in the presence of water. The film containing hide glue had a slight tacky feeling at all times, the glue apparently being somewhat hydroscopic. The substitution of locust bean gum completely eliminated this condition without affecting other characteristics of the film.

Continuity of both the unmodified and modified pectate films was obtained at coating weights somewhat less than 10 lbs./1000 sq. ft. and somewhat greater than 5 lbs./1000 sq. ft.

Neither the unmodified or the modified pectate films appeared to be affected in any way by immersion in turpentine or kerosene over a period of several days.

The times of penetration of five oily substances through a modified pectate coating containing locust bean gum as the adhesive are given below. The weight of this coating was 10 lbs./1000 sq. ft.

Oily Substance	Time of Penetration, hours
lard	between 48 and 72
turpentine	over 72
corn oil (Mazola)	between 48 and 72
hydrogenated vegetable oil (Spry)	between 48 and 72
mineral oil (Nujol)	between 48 and 72

Although the addition of urea and invert sugar to the pectate pulp did much toward improving the flexibility of the films, they were still not sufficiently extensible so that as a coating they would not break when the supporting board was creased.

CONCLUSION

These coatings are relatively cheap and despite their objectionable odor and color, have possibilities for some greaseproof application wherein the coated material is not subjected to severe creasing.

rbg/pl

PROJECT REPORT FORM

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INVESTIGATION OF FURANS FOR IMPROVING WET STIFFNESS OF PAPER

INTRODUCTION

Some previous work indicated that furfural and furfuryl alcohol under certain conditions of application improved the property of wet stiffness in paper. This presumably was due to polymerisation of these materials after their impregnation into the sheet. The improvement noted, however, was on a qualitative basis, and a quantitative confirmation was desired before seeking sponsorship for further development. This was done in two ways. One was to subject a corrugated board having a treated corrugated medium to flat crush tests after conditioning at high humidity, while the other was to make Taber stiffness tests on treated strips of paper after a 24-hour period of immersion in water. The treatments in both cases consisted of impregnation of corrugating medium with various solutions containing furfural or furfural and furfuryl alcohol together.

EXPERIMENTAL WORK AND RESULTS

Corrugated Board Evaluation

11" x 40" strips of 26# Chemfiber were dipped in furfural at various concentrations in 47.5% ethyl alcohol and then squeezed out by means of hand driven rubber press rolls. The concentrations were 10%, 30%, and 75%. In addition, one impregnation was made with 100% furfural.

The furfural used in these impregnations was very dark in color and practically insoluble in hot or cold water. It is possible that self-polymerization had taken place as it had been on hand for several years.

The treated strips after air-drying at room temperature were fabricated on the small laboratory corrugator into A flute single-face board. The single-face liner used was 9-point bogus. After fabrication, the boards were conditioned for 48 hours in a humidity box which was held at 81% R.H. and 73° F. The H and D flat crush machine was set up in the humidity box and tests were run in the box at the end of the 48-hour period.

The results of these tests along with data concerning the treatments are shown in Table I.

Taber Stiffness Evaluation

2" x 10" strips of 26# Chemfiber and Bogus corrugating medium were dipped in various solutions and squeezed out on hand driven rubber press rolls. Ten strips of each medium were so treated in each of 8 different solutions. These 8 solutions are summarized in Table II. The furfural used for these solutions was the same as for the corrugated board evaluation. However, in this case, both the furfural and the furfuryl alcohol were purified by distillation. The distillates were both light straw colored, the furfural being slightly darker. Subsequent to the impregnation treatment, the strips were placed in an air-circulating oven set at 105° C. for a period of 30 minutes. The treated strips were then submitted via the code office to the paper testing group for

TABLE I

EFFECT OF FURFURAL IMPREGNATION OF CORRUGATING MEDIUM ON A FLAT CRUSH TEST OF THE FABRICATED BOARD

Sheet Number	Concentration of Furfural in Dipping Solution, %	pH of Dipping Solution	% Furfural Pickup	Flat Crush, p.s.i.
Control	-	-	0	18
1	30	3.5	26.2	16
2	30	3.5	27.0	16
3	30	3.5	27.1	16
4	75	3.0	46.5	15
5	75	3.0	44.5	15
6	75	3.0	45.5	14
7	100	1.9	48.6	**
8	100	1.9	49.5	**
9	100	1.9	48.3	**
10	10	4.8	9.4	**
11	10	4.8	9.2	**
12	10	4.8	9.8	**

* untreated corrugating medium
** Specimens #7-12 were wrecked in the fabricator so test results could not be obtained.

TABLE II

EFFECT OF VARIOUS IMPREGNATION TREATMENTS ON WET TABER STIFFNESS OF TWO CORRUGATING MEDIUMS

Treatment Number	Strip Numbers	Impregnating Solution	Corrugating Medium	% Pick-up*	Average Initial Taber Stiffness Units**	% Improvement***	Average Normal Taber Stiffness Units**	% Improvement ***
0	1-10	100% furfural	Chemfiber	49.2	3.8	+ 5.6	2.6	+ 4.0
1	11-20		Bogus	47.3	4.7	+17.5	3.4	+41.6
2	21-30	98 parts furfural, 2 parts boric acid, 30 parts 47.5% C_2H_5OH	Chemfiber	39.1	4.5	25.0	2.8	+12.0
3	31-40		Bogus	39.1	4.4	+10.0	3.3	+37.5
4	41-50	98 parts furfural, 32 parts 47.5% C_2H_5OH	Chemfiber	37.8	4.2	+16.7	2.9	+16.0
5	51-60		Bogus	38.6	4.2	+ 5.0	3.2	+33.3
6	61-70	50 parts furfural, 50 parts furfuryl alcohol	Chemfiber	47.3	4.2	+16.7	3.0	+20.0
7	71-80			45.1	4.4	+10.0	3.4	+41.6
8	81-90	49 parts furfural, 49 parts furfuryl alcohol, 2 parts boric acid, 30 parts 47.5% C_2H_5OH	Chemfiber	38.6	3.9	+ 8.3	2.6	+ 4.0
9	91-100		Bogus	38.5	4.0	0	3.0	+25.0
10	101-110	49 parts furfural, 49 parts furfuryl alcohol, 32 parts 47.5% C_2H_5OH	Chemfiber	36.7	4.4	+22.2	2.8	+12.0
11	111-120		Bogus	37.5	4.3	+ 7.5	3.1	+29.2
12	121-130	47.5% C_2H_5OH	Chemfiber	0	2.9	-24.1	1.9	-24.0
13	131-140		Bogus	0	3.4	-15.0	2.0	-16.2
-	-	No treatment	Chemfiber	0	3.6	-	2.5	-
			Bogus	0	4.0	-	2.4	-

*% pickup represents all components of solution except water and ethyl alcohol.

**Five tests were made for each treatment although ten strips were submitted.

***Percentage improvement is based on values obtained for untreated specimens.

determination of initial and normal Taber stiffness in a water soaked condition (24-hour soaking in distilled water).

The Taber stiffness test consists of clamping one end of a strip of paper of specified dimensions in a set of jaws and attaching a small weight to the other end so that the strip hangs down and is free to swing back and forth as a pendulum. The jaws holding one end of the strip is rotated until the weighted end just touches a stop which prevents the strip from bending beyond an angle of approximately 10°. The angular displacement of the jaws in order to reach this point is the initial Taber stiffness. The normal Taber stiffness is determined by the angular displacement of jaws when after a one-minute period the free end of the strip holds itself just off the stop.

Table II summarizes the Taber stiffness reulsts as well as the desdription of the 8 impregnating solutions.

CONCLUSIONS

The results of the corrugated board evaluation involving flat crush tests were probably invalid due to the uncertainty of the purity of the furfural used.

The results of the Taber stiffness evaluation may be summarized in the following points.

1. In most cases, greater improvement of Initial Taber stiffness was obtained with the Chemfiber than with the Bogus while greater improvement of normal Taber stiffness was obtained with the Bogus than

with the Chemfiber.

2. The improvement in general was adversely affected by the presence of ethyl alcohol in the impregnation solution.

3. The improvement in general was not affected to any great degree by the presence of boric acid in the impregnating solution.

4. The improvement obtained from impregnating solutions containing furfural were in general the same as were obtained from solutions containing both furfural and furfuryl alcohol.

The use of furfural or furfuryl alcohol as an economical means of improving the wet stiffness of paper does not appear to be very promising. The improvement obtained is not in proportion to the costs involved. For example, it would cost approximately $170 per ton of corrugating medium treated for treatment #1 (Table II) which produced an improvement in normal Taber wet stiffness of 41%.

rbg/mmm

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PAGE 103-104 & 109-110
SIGNED Frans Vaurio
Frans Vaurio

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FOAMABLE PHENOLIC RESIN REINFORCEMENT OF CORRUGATED BOARD

INTRODUCTION

The purpose of this study was to determine the feasibility of using newly developed foamable phenolic resins for stiffening and waterproofing corrugated board.

PROCEDURE

A special steel tube was slotted so as to take the thickness of corrugated board without crushing the flutes. The board to be treated with the foamable resin was inserted into the slot and the joint sealed with Scotch masking tape. The Bakelite resin was weighed out and mixed with an acid catalyst. The mix was quickly poured into the tube and the ends of the tube sealed with rubber stoppers. The tube was rotated so that gravity aided the movement of the foaming resin into the flutes. Other methods of treating the board were tried without much improvement. A vacuum treatment was tried with a brass manifold but was too cumbersone and easily plugged with the hardened resin. Air pressure was also tried with the slotted tube but the rate of curing was so rapid that no advantage could be seen. The resin cured at room temperature.

The treated board was then submitted for flat crush tests by the Container Laboratory.

RESULTS

Board: 42# Kraft Liner, 28# Semichemical Corrugating Medium

Resin: 100 Grams Bakelite Foam Resin 50/50 L-2785-31. Whipped with air for one minute.

Catalyst: 6 ml. Catalyst ED 50-49

Reaction Time: Five to seven seconds

FLAT CRUST TEST

	Flat Crush, psi.	Specimen weight, grams 2.5 inch circle
Treated (av. of 12)	122	3.374
Untreated Control (av. of 9)	24	2.123

DISCUSSION

The foamed resin gave a 407 per cent increase in flat crush strength for an 82.5% increase in weight.

This would not be acceptable from an economic point of view as it would require 109 lbs. of resin to treat 1000 square feet. Although the cost of the resin used has not been established as yet it may be safely assumed that the cost will be well above a normal phenolic resin which today sells for approximately twenty cents per pound. Taking the extreme case and assuming this as the cost of the resin we would still have a cost of $21.80 per 1000 square feet of board. The possibility of treating, say, every tenth flute or reducing the density of the foamed resin would certainly cut the cost considerably and still give appreciable improvement in strength. However, with the present market conditions we cannot foresee an economic solution to the problem of cost. However, unknown future events

may take place to open up the feasibility of this type of treatment. Possibly other foamable materials may be considered for today's market conditions.

The experimental preliminary specimens are not indicative of commercial application possibilities. None of the samples were made full width. However, it is still somewhat of a problem as to how such a material could be used in machine operation. Possibly it would be well to try to spray the resin and the acid in such a way that the two would mix in the spray before hitting the paper. For the next tests this could be tried on the corrugator or on the single facing prior to combining. The sprayed resin might serve as the adhesive in such tests.

Another idea would be to apply the resin with a paddle wheel applicator, as in printing, to deposit the resin as a single line and then spray with acid catalyst before combining. The cured resin is insoluble in all known solvents and hence it is well to prevent the catalyzed resin from contacting machine parts which would be hard to clean. The uncured resin can be removed by washing with a solution of caustic soda, or possibly acetone.

Since the resin cures at room temperature, it would require a little experimentation to learn what catalyst concentration and what grade of foam resin would be best suited to the higher temperatures met in regular corrugating operation.

CONCLUSIONS

The Foamable Phenolic Resin appears to be effective in reinforcing corrugated board. A 407% improvement in strength could be shown with hand prepared samples.

The cost of the treatment as tried would probably be too high for practical application.

The preliminary tests should be followed up by tests on a continuous machine operation.

The use of other foamed materials like starches, proteins, and silicates might be cheaper and still serve as stiffening reinforcement.

Frem Davis

fv/sf

PROJECT REPORT FORM

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EFFECT OF BEATER ADDITION OF SYNCO 721 LIQUID PHENOLIC RESIN ON DIMENSIONAL STABILITY OF BLEACHED SULFITE PAPER

INTRODUCTION

The evaluation of Snyder Chemical Corporation Synco 721 for achieving improved dimensional stability in paper has been the object of this study.

Cellulose fibers are normally very sensitive to changes in moisture content which causes appreciable swelling.

According to various studies this swelling appears to be an intermicellar process. Most of the dimensional change is in a direction transverse to the fiber length or along the fiber diameter. The fiber length may suffer a change of a little over one per cent while the diameter may change as much as twenty per cent.

The most effective treatments which have come to our attention have involved chemical modification of the fiber by heat or reactive chemicals. Heating of wood under anaerobic conditions is reported to produce as high as 50% improvement in dimensional stability against changes in relative humidity. The reduction in hygroexpansivity was doubled for each 10° rise in temperature according to work done by Stamm at Forest Products Laboratory.

Treatment of fibers with resin producing chemicals such as phenol with formaldehyde and urea and formaldehyde has been reported to give as high as 57 to 75% retardation in change of dimensions of wood per unit dimensional change of the control. The urea resins are somewhat inferior to the phenolic resins.

Chemical treatment by replacing hydroxyl groups with acetyl groups has been found to give from 70 to 80% anti-shrink efficiency. This type of treatment is believed to be effective for two reasons--one is the bulking effect in which the oven-dry volume is increased and the other is due to the replacement of hydrophyllic groups with hydrophobic groups. The use of pyridine as a catalyst makes a vapor phase treatment possible with wood which is swelled by pyridine. Cellulose is reported as not being swelled by the pyridine and hence this treatment may not be as effective with paper.

This report covers a limited study of the improvement of dimensional stability of paper through the use of a beater additive phenolic resin. The Snyder Chemical Corporation Syncc 721 was used as the beater additive liquid phenolic in conjunction with bleached sulfite.

PROCEDURE

Bleached Weyerhaeuser standard sulfite pulp was beaten to a freeness of 500 S.-R. at 1.7% consistency in a one-pound Valley laboratory beater. The beaten stock was dewatered and tested for consistency.

A constant weight of 100 grams of oven-dry fiber was used in all trials. The dewatered pulp was diluted with distilled water to a con-

sistency of 3% in a special mixer equipped with a spiral agitator. After the pulp had been slurried for a few minutes at high speed, the pulp was heated to 90° F. and the resin solution (Synco 721), diluted with an equal weight of water, was then added to the warm pulp slurry and allowed to mix for another ten to fifteen minutes. Sufficient precipitant "K" was added to lower the pH to somewhere between 4.35 and 4.80.

The resin-filled pulp was then diluted to 0.5% consistency with distilled water and used in forming sheets on an 8 x 8" sheet mold equipped with a recirculating white water system.

The wet sheets were pressed between blotters at 65 p.s.i. for three minutes and then dried at 275° F. on blotters on a copper cylinder for five to seven minutes. All of the sheets were given a final heat treatment of one minute at 350° F.

The finished sheets were tested for hygroexpansivity at equilibrium with various humidities using the Neenah expansimeter.

The same procedure except for the beating was used with unbeaten sulfite in preparing handsheets. A little difficulty was experienced with the light weight unbeaten blank in forming sheets due to the tendency to stick to the wire.

RESULTS

The results are outlined in Table I and Figure 1. Figure 1 does not take into account the slight difference in per cent relative humidity shown in Table I for the measurement of initial length. The significant

differences are shown for the same change in per cent relative humidity.

The paper became increasingly less susceptible to humidity changes as measured by the expansivity as the per cent resin increased.

There was no consistent effect of basis weight on the hygroexpansivity of unbeaten sheets with no resin, although a trend toward increased hygroexpansivity appears to be indicated.

The sheets were rendered quite yellow from the resin addition.

DISCUSSION

From the information available one may surmise that part of the improvement in hygroexpansivity found for the beaten stock as compared to the unbeaten stock is due to the greater retention of the resin.

Similarly the heavier basis weights would tend to have an improved hygroexpansivity due to a better retention of resin.

Information as to the mechanism of stabilization of hygroexpansivity would throw more light on the reason beating improves the efficiency of the resin in reducing hygroexpansivity.

CONCLUSIONS

The Snyder Chemical Corporation liquid beater addition resin, Synco 721, reduces the hygroexpansivity of bleached sulfite paper at a sacrifice of color.

The improvement in hygroexpansivity stabilization is especially apparent in the case of beaten stock.

An increase in basis weight appears to increase the stabilization efficiency of the resin.

Apparently a more fibrillated and thicker sheet enhances the retention of the resin or affects the distribution in such a manner that the net reduction in hygroexpansivity is greater than observed with lighter weight sheets and unbeaten stock.

Beating appears to cause a very pronounced increase in hygroexpansivity of the paper without resin.

It can be seen that the resin treatment gave but slight improvement in the hygroexpansivity of the paper made with unbeaten pulp.

The beater addition resin reduced the hygroexpansivity of the beaten stock to a value lower than that of unbeaten stock. The lower resin content did very little for the sheets. It was not until 20% resin was added to the furnish that appreciable improvement is noted in the hygroexpansivity of the sheets.

fv/sf

REDUCTION OF HYGROEXPANSIVITY OF BLEACHED SULFITE WITH SYNCO 721 BEATER ADDITION RESIN

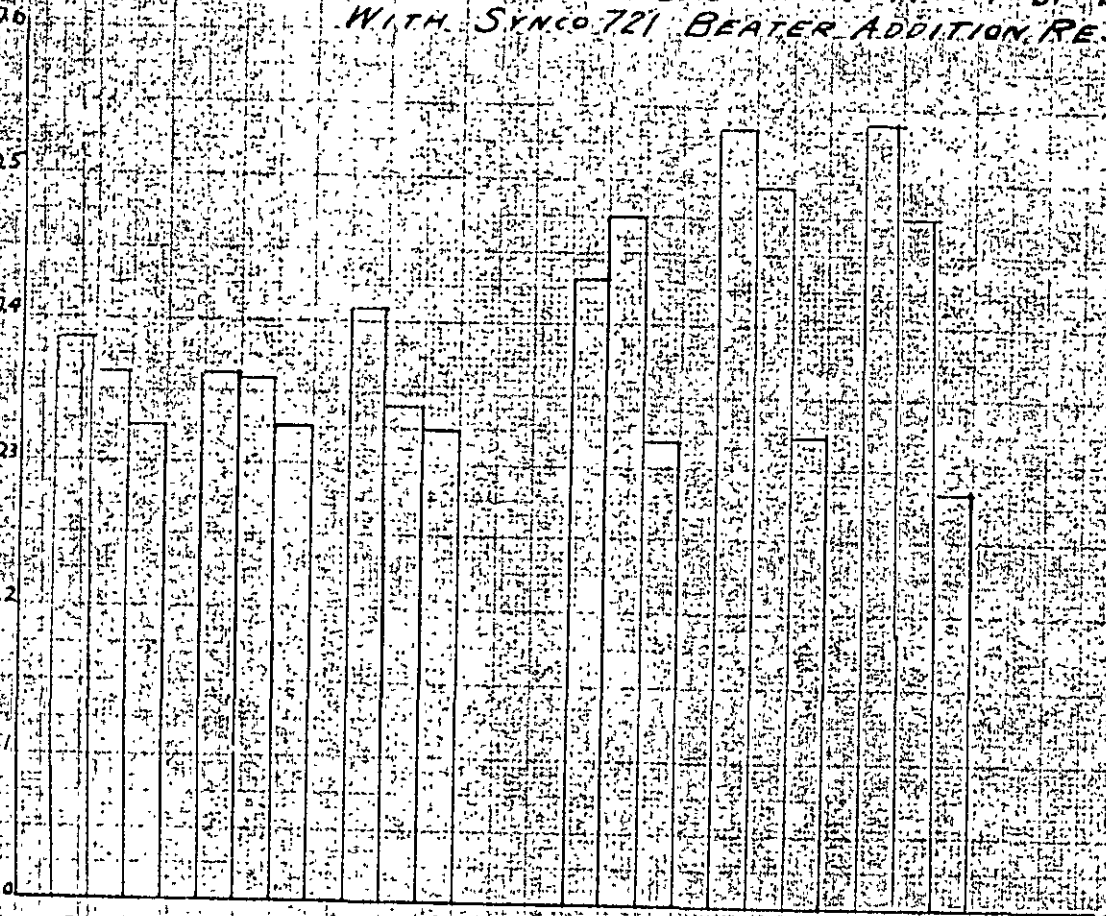

TABLE I

EFFECT OF BEATER ADDITION OF SYNCO 721 ON
HYGROEXPANSIVITY OF BLEACHED SULFITE

UNBEATEN STOCK

Light Weight Sheets

Synco 721 Resin, %	Description	Basis Wt. (lb. 25 x 40-500)	Hygroexpansivity, % (on Neenah expansimeter) 75.7% R.H.	75.7% to 64.2% R.H.	75.7% to 64.2% to 49.5% R.H.	75.7% to 64.2% to 49.5% to 33.3% R.H.
0	Unbeaten Bleached sulfite	65.8	0.0	0.110	0.263	0.384
10	Same	35.1	0.0	0.096	0.244	0.361
20	Same	58.1	0.0	0.083	0.214	0.325
Medium Weight Sheets--No Beating						
0	Unbeaten Bleached sulfite	90.3	0.0	0.104	0.249	0.361
10	Same	84.3	0.0	00.094	0.227	0.340
20	Same	80.9	0.0	0.088	0.215	0.323
Heavy Weight Sheets--No Beating						
0	Unbeaten Bleached sulfite	122.0	0.0	0.115	0.283	0.407
10	Same	84.3	0.0	0.094	0.227	0.340
20	Same	122.0	0.0	0.080	0.237	0.339

TABLE I (CONT.)

EFFECT OF BEATER ADDITION OF SYNCO 721 ON HYGROEXPANSIVITY OF BLEACHED SULFITE

BEATEN SHEETS (500 S.R.-FREENESS)

Synco 721 Resin, %	Description	Basis Wt. (lb. 25 x 40-500)	74.7%	Hygroexpansivity, % 74.7% to 64.0% R.H.	74.7% to 64.0% to 48.3% R.H.	74.7% to 64.0% to 48.3% to 33.8% R.H.
Light Weight Sheets						
0	Beaten Bleached Sulfite*	55.0	0.00	0.110	0.286	0.430
10	Same	53.4	0.00	0.126	0.325	0.474
20	Same	53.1	0.00	0.078	0.206	0.317
Medium Weight Sheets						
0	Beaten Bleached Sulfite	116.0	0.00	0.145	0.357	0.534
10	Same	81.2	0.00	0.127	0.331	0.495
20	Same	76.9	0.00	0.082	0.212	0.321
Heavy Weight Sheets						
0	Beaten Bleached Sulfite	125	0.00	0.143	0.357	0.538
10	Same	112	0.00	0.124	0.312	0.474
20	Same	104	0.00	0.058	0.176	0.282

* This was run under same conditions as unbeaten sheets.

Note 1. All hygroexpansivity specimens were conditioned to 50% and 84% respectively before obtaining the expansivity values.